

Basin-specific rates of incorporation of bomb-produced ^{14}C in fish otoliths: an example from the north Pacific Ocean

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Abstract

A collaborative study between the International Pacific Halibut Commission and the Alaska Fisheries Science Center has been initiated to test the hypothesis that eastern Bering Sea bomb radiocarbon concentrations during the years of 1944 to 1981 were different from those of the Gulf of Alaska during the same time. Upon completion, the eastern Bering Sea radiometric curve will be compared to the Gulf of Alaska radiocarbon curve created by the IPHC in 2003. Preliminary analysis suggests the onset of atmospheric ^{14}C in the Bering Sea indeed preceded the Gulf of Alaska in both time and signal strength. Otoliths from 33 Pacific halibut, ages one to six years, were selected to create the radiocarbon curve, and otoliths from 31 older Pacific halibut, ranging up to 29 years of age, were selected to create the validation points.

Background

A second radiocarbon curve experiment was needed to better understand why an initial radiocarbon curve, created with one-year-old halibut from the Gulf of Alaska (GOA) (Piner and Wischniowski 2004), did not validate ages of non-halibut species from the eastern Bering Sea (EBS) using radiocarbon. Several agencies have used the halibut radiocarbon curve created in 2003 to validate their age determination methodologies with good success. These comparisons were made with species caught in the GOA. Recently, the Alaska Fisheries Science Center (AFSC) used the halibut radiocarbon curve in an attempt to validate age determination methodologies used on EBS species. The $\delta^{14}\text{C}$ values extracted from the otolith cores of two EBS species, yellowfin sole (*Limanda aspera*) and Greenland turbot (*Reinhardtius hippoglossoides*), were plotted against the halibut radiocarbon curve from the GOA. Results suggest that these core samples are younger than what microstructural ageing would indicate. Since the techniques utilized in age determination of EBS species are the same as those for the GOA species, we can rule out the ageing technique as the source of error. The most apparent conclusion would suggest that ageing error is the source of these differences, and is most probable in the case of Greenland turbot because they are notoriously

difficult to age. They often have checks (false annuli) interpreted in their age assignments. This misinterpretation would almost certainly lead to an overestimation of age. However, in the case of yellowfin sole, the annuli are extremely clear and well delineated, with rarely any inclusion of checks; consequently, this allows for ease of age assignment. Here, it is highly unusual that the radiocarbon age is younger than the microstructural age; classically the opposite is observed. This would suggest that yellowfin sole ages are overestimated and would indicate that features which are currently interpreted as annuli are deposited on yellowfin sole otoliths more than once per year. There are very few species globally that demonstrate this occurrence (Irvine et al. 2007, Sokolov and Malyutin 1978), and to date, no commercially-collected species in the northeast Pacific reveal this type of deposition. An alternate explanation is that the EBS, because of its unique oceanographic conditions, responded differently than the GOA during the peak times of nuclear atmospheric testing in regard to the uptake of atmospheric ^{14}C . The rate at which ^{14}C moves through a body of water may be attributed to factors such as current, wind, ^{14}C reservoirs, and water depth. It is hypothesized that the atmospheric ^{14}C signature may have traveled through the EBS at a faster rate than it did through the GOA, resulting in an earlier ^{14}C pulse which was incorporated into all EBS species alive at that time. This would explain the radiometric underestimation of age for yellowfin sole.

Preliminary analysis indicates that the reference chronology curves developed for the EBS and GOA are markedly different. The EBS curve displays an earlier and more rapid increase in ^{14}C , a substantially higher ^{14}C peak, and an exponential post-peak decay that is much less pronounced in the GOA (Figure 1). Specifically, we are interested in testing: *i*) differences in the functional form of the GOA and EBS reference curves using a coupled-function model, *ii*) differences in the functional forms of the EBS validation sample and the new EBS reference chronology, and *iii*) the probability of ageing bias for EBS samples. Given these objectives, Bayesian inference provides advantages over other inferential approaches because it explicitly estimates uncertainty in model parameters and functions of those parameters, provides a convenient framework for evaluating a suite of candidate models (Gelman et al. 2003), and, for this example, is a probabilistic means of quantifying any ageing bias.

References

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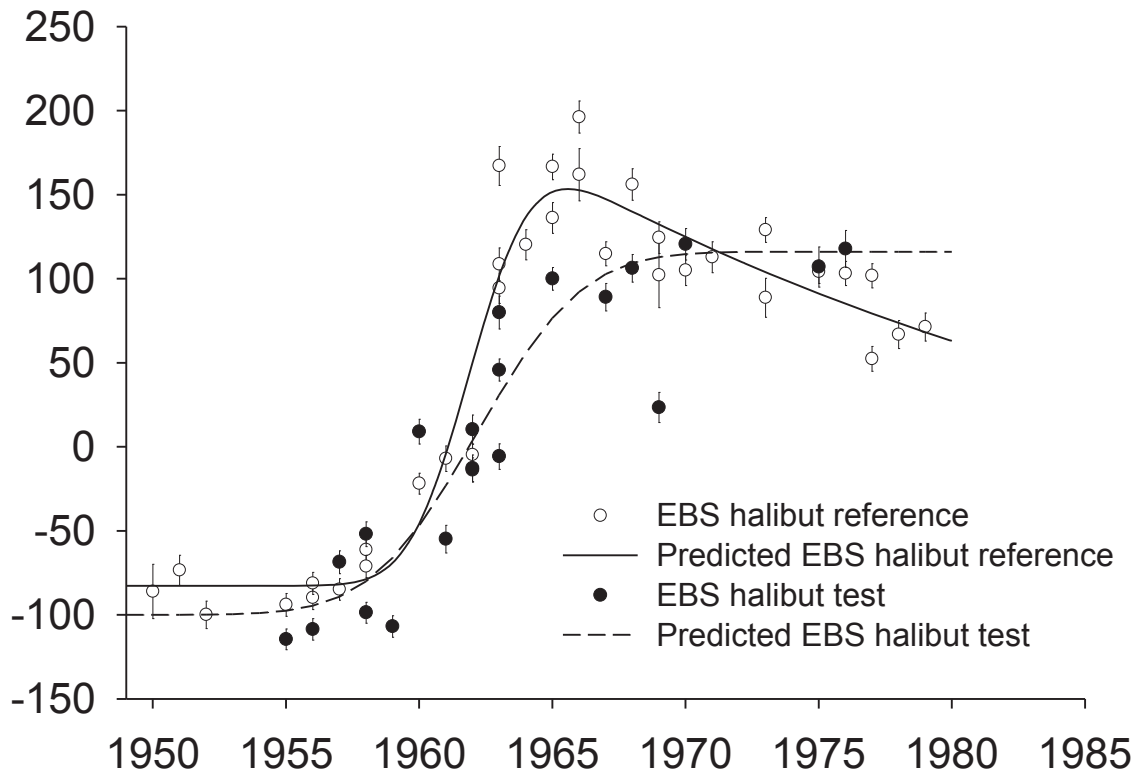


Figure 1. Comparison of the eastern Bering Sea and the Gulf of Alaska radiocarbon reference chronologies.

